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A Secure Web-Based Examination Management System for Higher Institutions

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ABSTRACT: The widespread use of digital technology in higher education has also been responsible for changes to how exams are run, with regard to administration, delivery, and assessment. In spite of the improvements made, most universities in Nigeria are still relying heavily upon old fashioned paper-based exam systems that can no longer cope with an increasing number of students. Many of these traditional methods have significant logistical inefficiencies; they take a long time to process results; they create excessive administrative burdens; and they are susceptible to errors created by humans. Exams in Nigerian universities have also been plagued by cheating scandals (such as impersonation), and by the lack of transparency in the assessments themselves, resulting in a loss of confidence in the fairness of assessments. This research will develop a secure on-line Exam Management System (EMS), which will help to improve the operational efficiency and integrity of examinations across higher education institutions. To achieve this, the proposed EMS will include a multi-layered authentication model that includes both password-based login, one-time password (OTP) validation, and biometric authentication. Additionally, the proposed EMS will offer features including automated exam scheduling, randomizing questions, electronic monitoring during exams, real time calculation and reporting, and generation of reports. The proposed system should help minimize the amount of time spent on administrative work, as well as errors that occur during traditional manual processes. It is also anticipated that the proposed system will increase transparency in the results of examinations, and make them more reliable. Ultimately, by helping address some of the shortcomings of traditional assessment methods, the proposed system will support the transition of higher education into a more digital environment; promote assessment that is secure, scalable, and cost-efficient; and protect academic integrity.

KEYWORDS: Online Proctoring, Examination Management System (EMS), Academic Integrity, Multifactor Authentication (MFA), Examination Security.

I. INTRODUCTION

The development of digital technology has changed the way examinations are administered in schools, leading to a new generation of automated test administration systems. Automated testing is defined as "the use of computer-based systems to administer, score, report and display results from educational tests and assessments". Automated testing systems are becoming increasingly popular because they offer fast turnaround time, better data protection, and reduced administrative burden compared to traditional paper-and-pencil testing systems [2]. With increasing adoption of e-learning and digital learning platforms by educational institutions, there will be an ongoing requirement for high-quality and reliable examination systems.

An Examination Management System (EMS) provides a complete solution for managing all aspects of examinations, including student registration, question development and management, examination scheduling, invigilation, calculating results, and reporting. The use of an EMS can provide a streamlined approach to the management of examinations and improve communication with all stakeholders involved in the process, including students, lecturers, and administrators [3]. The success of an EMS depends on how well it is implemented and how effective it is at providing transparency, reducing the time required to perform administrative tasks associated with conducting examinations, and ensuring academic integrity through the use of features that help protect

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against cheating and other forms of academic dishonesty. The effectiveness of an EMS also depends on its ability to be usable by faculty members, staff, and students; have adequate security measures to prevent unauthorized access; and meet the specific needs of each institution.

Although there have been considerable advances in how assessments are conducted at the higher education level, many educational institutions continue to use the same traditional paper-based methods to administer their exams. Paper-and-pen based methods of administering exams remain the norm in many educational institutions, especially in developing countries [4],[5]. Although paper-and-pen based systems have been used as long as they have been available, they are less efficient and sustainable than ever before due to the increasing numbers of students and the need for rapid and secure assessment. The traditional method of administering an exam utilizes a number of components that are labor intensive and subject to human error. These components include the physical delivery of exam material, the manual supervision of exams (invigilation) and the use of humans to evaluate the student's work. The traditional paper-and-pen method of administering exams is plagued by numerous problems. Perhaps the most significant problem is the logistics of printing, packaging and physically delivering question papers, which can cause delays and increased administrative costs. In addition to being time consuming, manual evaluation of student exams is also vulnerable to variations and biases, which negatively affect the validity and reliability of the results.

In addition, many times there are compromises made with the security of the test materials, this leads to an increase in the number of exam papers being leaked and undermines the trustworthiness of the testing process. Impersonation and cheating still continue to be a problem in the traditional testing environment. Without a means to identify and monitor students during the testing process, it makes it much easier for individuals to write exams for other people or commit some form of academic dishonesty [6]. The cumulative impact of these issues creates inefficiency, lack of integrity and a loss of transparency within the testing process; ultimately creating a negative effect on the quality of educational services [7]. To overcome the mentioned issues, examination management systems are becoming an alternative. they use internet technologies to enable remote access, real-time monitoring, and automated processes, therefore improving efficiency and accessibility [8].

A secure web-based examination system has been proposed to address current problems with the traditional method of examinations in higher institutions. The Proposed System will feature Multifactor Authentication (MFA) to increase security by requiring users to verify their identity through multiple methods, therefore reducing the risk of unauthorized access. The focus of the work is to propose a model for developing a secured Web-Based Examination Management System that addresses the inherent flaws of the traditional examination method; enhancing examination integrity and promoting digital innovation adoption in the education sector.

II SIGNIFICANCE OF THE STUDY

The proposed design for a multifactor authenticated web-based examination management system for higher education is significant for all educational institutions as it will address many of the serious issues and shortcomings of the current paper-based examinations. For example, impersonations, theft of examination papers and manual scoring errors are common problems with paper-based examinations [9]-[11]. In addition to addressing these issues, by including multifactor authentication the proposed web-based system will provide an additional layer of protection to ensure that only those who have been granted authority will be able to access and take examinations [12], thereby protecting the validity of assessments and fostering confidence in the assessment process.

In addition to this, the research is providing a functional and scalable option in using current technologies to facilitate a university/college's transition into secure, online testing environments [13]. The researchers, developers, and policy makers will also be able to use the results of the study along with its approach to implement future enhancements or expansions (i.e., learning management systems, mobile platforms). Overall, the research facilitates an educational institution's move toward the digital age through an affordable, secure, and efficient test administration process specifically designed to meet the needs of institutions of higher education.

III LITERATURE REVIEW

The literature review presents a study on how test delivery has transitioned from paper-based tests to computer- and/or web-based testing systems. This is provided through an overview of the use of computerized exams and the benefits provided for efficiency, security, and transparency via the Examination Management System (EMS). Traditional Paper-Based Testing (PB) will be contrasted with Modern Exam Delivery Methods (MEDM), focusing on issues that arise due to PB such as manual error, administrative burden, etc. Web based EMS security

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will be examined further to determine its ability to provide an integrity-based environment. A discussion regarding exam eligibility, assessments in higher education and grading systems will also take place. Finally, this review will examine related research and demonstrate the increased relevance and effectiveness of technology driven assessment processes in today's educational systems.

A. Computerized Examination

Computerized exams are becoming more and more common in educational institutions around the world. The main reasons for this trend are many; these include greater efficiency, faster scoring and feedback, and better security than traditional paper-based assessments. The primary advantage of computer-based tests (CBTs) is that they offer an opportunity to score and give immediate feedback to the student. This type of quick and detailed feedback can greatly help a student's learning process. For example, a study done by the University of the Pacific indicated that students were very appreciative of the quick and detailed feedback they received from computer-based testing platforms [14] that assisted them in their learning process. A second advantage of computer-based tests is that they significantly reduce human error that occurs when hand-scoring a test, thus providing the student with a more accurate assessment of his or her knowledge.

The use of digital proctoring systems, which employ sophisticated algorithms and surveillance technologies to oversee exams, is being used by institutions to support academic integrity; however, the adoption of these systems has raised questions regarding the privacy and ethics of continuously monitoring students [15]. Computer-based testing (CBT) presents a variety of advantages including increased efficiency and instant evaluation but it also represents problems which institutions need to solve when implementing CBTs in educational environments; namely ensuring an adequate computing system, protecting the security of the test environment, and identifying potential issues with ethics.

B. Examination Management System

Modern educational institutions rely on Examination Management Systems (EMS) for managing assessment and reducing problems that are associated with paper-based examinations; paper-based examinations can experience logistical problems, manually grading error and potential security breaches. EMS can help alleviate these problems through automated process which include exam scheduling, generating questions, registering candidates and processing results that provide greater efficiencies and accuracy [17]. One of the most important aspects when conducting an examination is security. Many EMS applications utilize strong security features which include user identification and access control to maintain the integrity of the examination process [18]. In addition to security features, some EMS applications use advanced technology, such as biometric validation and secure web browsing, to prevent students from cheating during online assessments [19],[20].

Although EMS has several advantages in terms of education and technology, EMS is still difficult to implement by institutions. Therefore, institutions will need to address issues with respect to technology (e.g., connectivity to the Internet and availability of technology), educator/student training, and resistance to changes in order to successfully implement EMS [21] as well as provide a stable means of accessing EMS technology for both students and teachers [22]. EMS is a major step forward in the use of educational assessment technologies, providing educators with improved efficiencies, security, and ability to manage data in the use of EMS. There are many difficulties in implementing EMS, the benefits EMS provides in the area of providing fair and efficient testing processes make it increasingly important in today's education environment.

C. Traditional Paper Based Examination and Web-Based Examination Systems

Traditional paper-based testing requires students to answer questions by hand with pen and paper in a proctored environment. The reasons traditional paper-based testing is still so common include its familiar nature, low level of technology required and its reliability. Paper based testing is also cost effective for educational institutions who have little or no digital capability and it does not require the same type of technical support as other forms of testing [23]. While traditional paper-based testing has many advantages (i.e., very few administrative tasks) there are some disadvantages including the environmental impact and less flexibility in the design of test items. Depending upon how the test items are designed; traditional paper-based testing can be used to measure several different skill areas, i.e., essay writing, multiple choice questions and problem solving. Although these formats of test items are effective at measuring a variety of skills depending upon the format; it is often very time consuming to score them and may be subject to the errors associated with human judgment [24];[25].

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The use of web-based assessment technology enables students to complete examinations remotely using Internet technologies to administer assessments on-line; this offers greater flexibility for remote learners and reduces the burden associated with administration by automating grading and providing a digitally managed approach. Additionally, web-based assessment systems have enhanced security (e.g., randomizing question pools and authentication), [26] despite the advantages of web-based assessment systems, they may be difficult to implement due to technological requirements and issues related to academic integrity that are addressed through the use of remote proctoring. Innovative solutions such as the use of blockchain for secure record keeping and AI to monitor will continue to improve web-based assessment systems; web-based assessment has been successfully used at many educational institutions.

D. Security in Web-Based Examination Management Systems

The security of web-based Examination Management Systems will ensure that assessments remain confidential, authentic and secure. The potential security weaknesses within these systems include; unauthorized access to questions, leakage of question papers, impersonating students and cheating by students during examinations [27]. As a result of these weaknesses, several methods to maintain the security of examinations have been implemented. This includes encrypting communications, ensuring users authenticate themselves prior to accessing examination resources, controlling access based on the roles of individuals utilizing the system, and securing all candidate question banks. A strong, robust security architecture will be required to build confidence in web-based examinations, particularly in environments where high stakes examinations and certifications exist [28]. Proctoring (both live and AI-based) has become an integral part of many examination platforms used today. Proctoring uses webcam surveillance, browser lockdowns, and monitors the behavior of candidates to help prevent cheating and impersonation [29]. Biometric verification and 2 Factor Authentication (2FA) are also being used with increasing frequency to authenticate the identity of candidates [30]. However, to remain effective against continually evolving cyber threats, proctoring must continue to be updated and penetrated tested. In conclusion, the effectiveness and success of Web Based Examination systems is dependent upon the strength of the security framework utilized.

E. Security tools used in Web-Based Examinations

The growing use of distance learning and online systems for education has brought about the increased usage of web-based testing. As a result of security concerns relating to cheating, tampering with test results and unauthorized access to test results, a number of different types of tools have been developed to protect the testing process. These tools include; authentication and authorization tools, proctoring tools, secure browsers and lockdown tools, tools that provide encryption for sensitive data as well as privacy protection for data, and blockchain technology.

F. Related Works

[31] researchers developed a web-based online evaluation information system to improve the quality of learning evaluation for students. The system was developed with the waterfall model for elementary schools assessment process. The researchers used the PHP and CodeIgniter framework to build the system and included several modules which were authentication module, question management module, examination participant module and real time results module. The researchers used black box testing to validate their system. One major advantage of this system is the detail design of the system and simplicity of the system to do evaluations. A disadvantage of the research is lack of attention to security, specifically encryption, multi-factor authentication, or proctoring tool; therefore, the system is not suitable for higher education where test integrity is crucial. Also, the researchers did not consider the issue of scalability, or the integration of institutional data bases. Therefore, there are some gaps in the study that your project will be able to address through emphasis of robust security, integration, and scalability to provide the system for higher education.
[32] the authors developed a Web-based platform that will help to automate and simplify the assessment process for educational institutions. The proposed system has the potential to include several functionalities including; user authentication, the administration of a question bank, the scheduling of exams, and automated grading. In this regard the system could greatly assist in increasing efficiency and reducing the time spent by staff manually processing exams. One of the major strengths of the proposed system is the simple-to-use interface of the system and the fact it can administer multiple exams at one time. This would be particularly useful for larger educational

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institutions that have large numbers of students. However, the authors do not discuss the use of enhanced security measures (for example; data encryption, secure authentication methods, and anti-cheating/anti-plagiarism) to ensure the integrity of the exams administered using their system. These are important considerations for institutions of higher education where the credibility of both faculty and students is paramount. The authors indicate the proposed system will be structured as a three-tiered architecture. The tiers will include the presentation layer, the business logic layer, and the data layer. The layered approach will provide the system with the benefits of modularity and scalability. The authors identify a significant limitation to the proposed system as being the lack of a substantial focus on developing robust security features and proctoring options. Therefore, the authors believe additional features should be added to the system to address these limitations in an environment typical of a post-secondary institution.

[33] developed a web-based testing system using AI to remotely proctor online tests to improve their authenticity and reliability. The proposed system uses webcam video to monitor test-takers, captures the entire screen and/or the application window (in the case of web-based applications), and has a decision-based inference method to identify and thwart potential cheating. One of the greatest advantages of this system is that it allows for secure timed testing to be conducted entirely online, and therefore is very useful for online learning models. In addition to allowing timed testing, the system also offers automated scoring of descriptive type questions, through keyword frequency and linguistic pattern analysis to allow for rapid marking. However, the authors failed to provide detail about how scalable the system would be to support a large number of test-takers, or how adaptable it would be to other types of academic environments. The methodology used to process test-taker responses included preprocessing the student response data, identifying keywords from the data, and comparing the keyword frequencies to those of the model answers to produce a score. Therefore, the primary area of concern with respect to this proposed system was that it does not appear to have been designed to be scalable or adaptable to fit into larger scale institutionalized academic settings. As such, additional research will be necessary to develop scalable and adaptable systems in support of large-scale academic settings.

Multi-factor authentication has gained significant attention as an alternative to traditional password authentication methods for providing stronger security for users. In addition, many researchers have suggested multi-factor authentication methods for strengthening examination systems' security [34],[35]. A recent study by Ibebuogu and Ukachukwu provided a demonstration of using multi-factor authentication, which includes biometric verification in exam systems [35]. Previous studies demonstrated the use of multi-factor authentication (including OTP, biometric and knowledge factors) for enhancing the security of online examinations [35]. Furthermore, previous studies on SEMS also support the layering of an architectural approach used in this research study [37].

III METHODOLOGY

A. Research Design and System Requirements

The methodology focuses on the conceptual design and architectural modeling of a secure web-based examination management system rather than full-scale system deployment. It uses design science research methodology (DSRM). The proposed system is categorized into functional and functional requirement.

Functional Requirements	Non-Functional Requirements
User registration process to identify users based on their role.	Security Standards for the Web-Based Examination Management System.
Secure Login Process through Multifactor Authentication.	Usability Standards for Users in Higher Education Institutions.
Automated Grading & Result Generation for Exams	Accessibility Standards for Users with Disabilities.
Examination Scheduling Process with Audit Logs.	Academic Integrity Standards for Higher Education Institutions
Result processing and report generation	Data Confidentiality Standards for the Secure Web-Based Examination Management System.

The DSRM is well suited for developing and modeling an information system that solves an identified problem within an organization. In this case it allows the practical application of designing and architecting a secure web-

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based examination management system that meets the needs of higher education institutions in terms of being practical, scalable and secure.

B. Proposed System Architecture

This proposed system is structured in four (4) distinct layers for both functionality and security: User Layer; Presentation Layer; Application Layer; Data Layer. For additional security features, this system includes a Multifactor Authentication Module that incorporates two or more methods of verification: Password; One-Time-Password Verification; Biometric Verification. These security features ensure that examinations are delivered securely; monitored in real-time; stored encrypted; logged with audit records in order to protect the integrity of an examination.

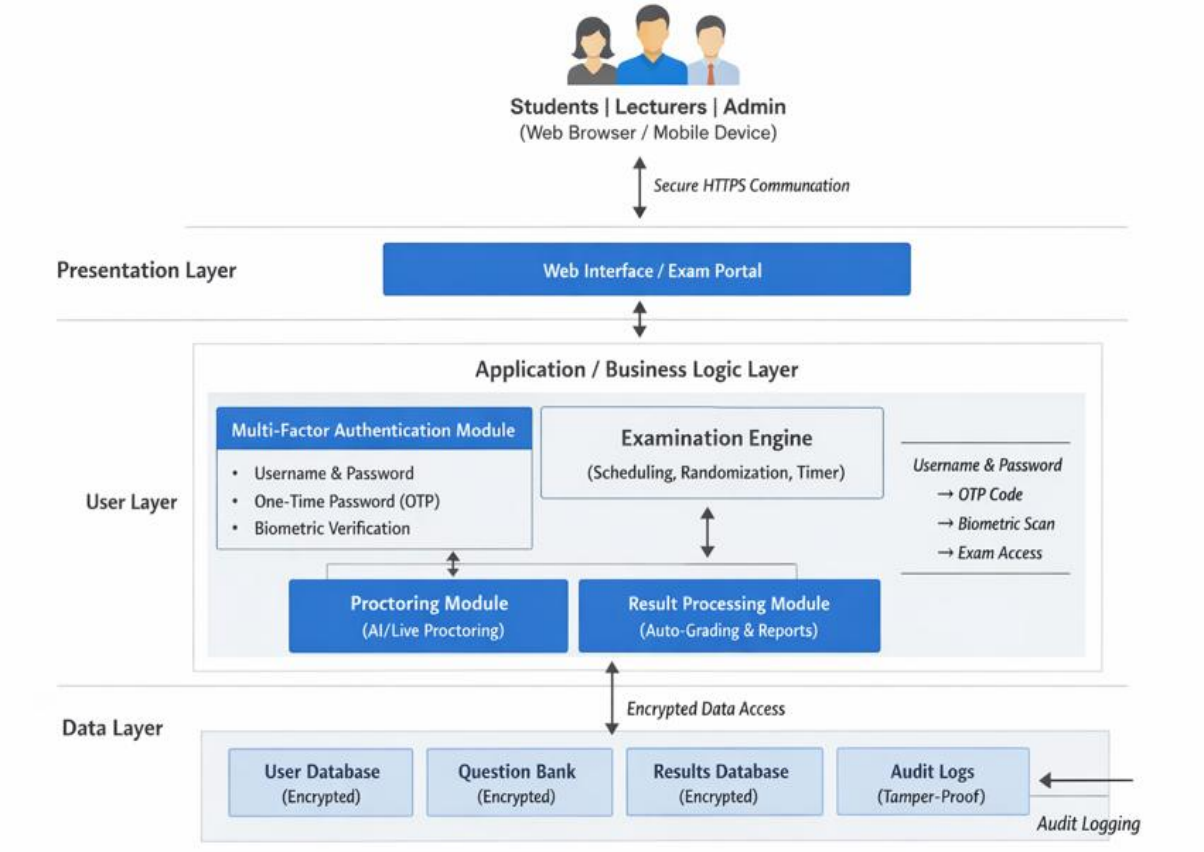

Figure 1: [34]; [35], Adapted framework for the secured web-based examination management system

The proposed system will be based on the three-tiered web architecture:

- ✓ Tier 1: Presentation Layer:
  This Tier enables users (students, lecturers, administrators) to use their web browser to access the system. Users can enter input into the system by way of the User Interface provided in this Tier. Examination Results and Feedback will also be presented to the user from this Tier.
- ✓ Tier 2: Application (Business Logic) Layer:
  This Tier will handle all of the "logic" of the system; including user authentication, enforcing rules for examinations, randomly selecting questions, controlling time, and calculating final exam results. All of the multi-factor authentication that is used to protect the security of the user accounts will be located within this Tier.
- ✓ Tier 3: Data Layer:
  All data stored by the application is contained within the Data Layer. This includes user account information, examination questions, final results, and system logs. Encryption is used to protect sensitive information from unauthorized access or theft.

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The proposed Web Based Examination Management System, with its multiple layers of security, uses a multi-level authentication process to ensure the security of each layer by utilizing a combination of a user name/password login, and a one-time password (OTPS) to authenticate users, as well as a biometric method to provide additional identification of users. Additionally, the system will contain a comprehensive testing and evaluation program which includes an examination engine that will handle the scheduling, the randomizing of questions, and the timing of examinations, as well as proctoring and module for automatic results processing. In addition, all data collected from the examinations will be stored in a database that has been encrypted so that they can be kept confidentially and their integrity will be maintained and there will be a record of all access to this data; therefore, the institution of higher education will have a secure and scalable architecture for their transition to a digital examination platform.

III CONCLUSION AND RECOMMENDATION

The study proposed the development of an examination administration tool that is both web-based and secure for use by Higher Education Institutions. Paper examinations are often limited by fraud and impersonation, inefficient logistics and slow processing of results; and have many other issues. In response to these problems, the proposed a designed of a multi-layered architecture which includes multiple-factor authentication (MFA) so as to increase the overall security and trustworthiness of examinations administered through the system.

The proposed architecture is designed with a modular concept of four levels: user layer; presentation layer; application layer; and data layer. These modular designs are to provide for increased flexibility and efficiency in maintaining and developing the systems. Multifactor authentication was used to improve security by requiring both a password; a one-time passcode; and (optional) use of biometrics to verify the identity of each user before they can access the system. The feature of the proposed architecture includes an examination engine, a proctoring module, automated grading functionality, and encrypted data storage. This will provide an open and efficient method of conducting examinations. Therefore, the overall design of this proposed system provides a realistic model to support the digital transformation of the examination process within higher education, while maintaining academic integrity.

Based on the outcome of this study, the following recommendations are made:

i. Higher education institutions (HEIs) can begin adopting digital web-based examination management systems for their examinations that have built-in multi-factor authentication, and also will provide a platform that increases the quality of their examination process by increasing integrity of the examination, decreasing administrative workloads, and enhancing overall operational efficiencies.
ii. The proposed digital examination management system should be integrated into an institution's current learning management systems (LMS) and student information systems, and it should be designed to accommodate larger scale examinations through infrastructure planning.
iii. To ensure continued enhancement in terms of security, and to prevent future security breaches in relation to examination malpractice, regular security audits and system updates should occur, along with the inclusion of additional proctoring and monitoring features.
iv. Future studies related to the implementation of the digital examination management system, its performance, and potential use of new technologies (such as artificial intelligence, and blockchain) should continue to develop and evaluate the security and integrity of HEI examinations.

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